

WHAT IS CLAIMED IS:

1. An image display apparatus comprising:
- reflective display means;
- illumination light source means for illuminating
- 5 the display means;
- an illumination optical system for guiding light from the illumination light source means to the display means; and
- a display optical system for guiding light from
- 10 the display means to an eye of an observer,
- wherein the illumination optical system and the display optical system share only one surface of optical surface A having two functions of transmission and reflection with each other, wherein a reference ray
- 15 emitted from the illumination light source means and passing a center of an image on the display means and a center of the eye is incident from the illumination light source means to the optical surface A, is reflected under a condition of an angle $\alpha(^{\circ})$ of $20 < \alpha$
- 20 < 80 between the entering reference ray and the reflected reference ray on the optical surface A, is incident substantially normally to the display means, is reflected thereby, is transmitted through the optical surface A, is reflected by a plurality of
- 25 decentered, reflective curvature surfaces, and thereafter is guided to the eye, and wherein the display optical system is comprised of an optical

Sub
C1
end

member comprising the optical surface A and another optical member having an optical refracting power, said optical members being placed with an air space in between.

5

2. The image display apparatus according to Claim 1, wherein the optical surface A in the illumination optical system is a reflective curvature surface having a positive refracting power on a local meridional section (a plane including incident light and exit light of the reference ray).

10

3. The image display apparatus according to Claim 1, wherein the illumination light source means is an RGB time division light source and the display means displays images of R, G, and B in time division in synchronism with emission of color light beams of R, G, and B from the RGB time division light source.

15

4. The image display apparatus according to Claim 1, wherein an angle $\beta(^{\circ})$ of incidence to the reflective display means, of the reference ray emitted from the illumination light source means satisfies the following condition:

20

$$-10 < \beta < 10.$$

25

5. The image display apparatus according to Claim

2 or 3, wherein the display optical system includes two or more surfaces with refracting powers differing depending upon azimuth angles, and the entire display optical system has a positive refracting power.

5

6. The image display apparatus according to Claim 5, wherein in an outermost image on a local meridional section of the display means (a plane including incident light and exit light of the reference ray), an F3 eye center ray represents a ray passing the center of the eye and an outermost image on the far side from the eye, $local_fy(F3)$ is a total focal length in the local meridional section of the display optical system on the F3 eye center ray, $local_fyC(F3)$ is a focal length in the local meridional section on a hit point of the F3 eye center ray on a transmissive surface C with a refracting power closest to the eye, and a ratio of the focal lengths satisfies the following condition:

10

15

$$-0.6 < local_fy(F3)/local_fyC(F3) < -0.1.$$

20

7. An image display apparatus comprising:
reflective display means;
illumination light source means for illuminating the display means;
an illumination optical system for guiding light from the illumination light source means to the display means; and

25

a display optical system for guiding light from the display means to an eye of an observer,

wherein an optical surface A having two functions of transmission and reflection, shared between the illumination optical system and the display optical system, has a curvature on a local meridional section (a plane including incident light and exit light of a reference ray emitted from the illumination light source means and passing a center of an image on the display means and a center of the eye), wherein when local_fy represents a focal length in the local meridional section of the display optical system and local_fyA a focal length in the local meridional section of only the optical surface A in the illumination optical system, a ratio of the focal lengths satisfies the following condition:

$$0.1 < \text{local_fyA}/\text{local_fy} < 1.0,$$

wherein rays emitted from the illumination light source means are reflected by the optical surface A to illuminate the display means and the reflected light from the display means is transmitted through the optical surface A, is reflected by a plurality of reflective surfaces, and thereafter is guided to the eye.

25

The image display apparatus according to Claim 1, wherein the optical surface A having the two

functions of transmission and reflection, shared between the illumination optical system and the display optical system, comprises only one surface.

5 ^{12.}
^{10.} The image display apparatus according to Claim ^{10.} wherein the plurality of reflective surfaces in the display optical system are decentered curvature surfaces.

10 ^{13.}
^{10.} The image display apparatus according to Claim ^{10.} wherein the display optical system is comprised of an optical member comprising the optical surface A and another optical member having an optical refracting power, said optical members being placed
15 with an air space in between.

^{14.}
20 ^{11.} The image display apparatus according to Claim ^{10.}, ^{11.}, ^{12.} or ^{13.} wherein the illumination light source means is an RGB time division light source and the display means displays images of R, G, and B in time division in synchronism with emission of color light beams of R, G, and B from the RGB time division light source.

25 ^{15.}
^{12.} The image display apparatus according to Claim ^{10.}, wherein the display optical system includes two or more surfaces with refracting powers differing

Sub D4 encl

depending upon azimuth angles, and the entire display optical system has a positive refracting power.

Sub 13 encl

13. An image display apparatus comprising:

5 reflective display means;

illumination means for illuminating the display means;

an illumination optical system for guiding light from the illumination means to the display means; and

10 a display optical system for guiding light from the display means toward an observer,

wherein the illumination optical system and the display optical system share an optical surface A having two functions of transmission and reflection

15 with each other, the optical surface A has a curvature on a local meridional section (a plane including incident light and exit light of a reference ray emitted from the illumination means and passing a center of an image on the display means and a center of

20 the pupil), a curved surface B is provided on the opposite side of the optical surface A to the display means, and the optical surface A and optical surface B compose a lens body, wherein rays emitted from the illumination means are reflected by the optical surface

25 A of the lens body to illuminate the display means, and the reflected light from the display means is transmitted by the optical surface A to enter the lens

body and then emerge from the optical surface B, is then reflected by a plurality of reflective surfaces, and thereafter is guided to the pupil to form an enlarged image of the image displayed on the display means, and wherein when local_ryA represents a radius of curvature in the local meridional section, at a point of intersection with the reference ray on the optical surface A of the lens body in the display optical system and local_ryB a radius of curvature in the local meridional section, at a point of intersection with the reference ray on the curved surface B, local_ryA and local_ryB have an identical sign and satisfy the following condition:

$$0.4 < \text{local_ryA}/\text{local_ryB} < 2.0.$$

The image display apparatus according to Claim 13, wherein the optical surface A having the two functions of transmission and reflection, shared between the illumination optical system and the display optical system, comprises only one surface.

The image display apparatus according to Claim 13, wherein the reflected light from the display means emerge from the lens body and thereafter is reflected by a plurality of reflective surfaces being decentered curvature surfaces to be guided to the pupil.

Sub
C3
end

00915455-072701

Sub
04

20.
16. The image display apparatus according to
Claim 13, 14, or 15, wherein said illumination means is
a time division light source for emitting a plurality
of color light beams in time division and the display
means displays images based on respective color beams
in time division in synchronism with emission of the
color light beams from the time division light source.

21.
17. The image display apparatus according to
Claim 13, 14, or 15, wherein the display optical system
includes two or more surfaces with refracting powers
differing depending upon azimuth angles, and the entire
display optical system has a positive refracting power.

22.
18. The image display apparatus according to
Claim 13, wherein said lens body is comprised of a
glass member.

23.
19. The image display apparatus according to
Claim 13, wherein said optical surface A and said
curved surface B are cylindrical surfaces.

24.
20. The image display apparatus according to
Claim 13, wherein said optical surface A is a half
mirror of metal.

25.
21. An image display apparatus comprising:
reflective display means;

09915455-072704

Sub
Op
encl

Sub
C4

illumination means for illuminating the display means;

an illumination optical system for guiding light from the illumination means to the display means; and

5 a display optical system for guiding light from the display means toward an observer,

wherein the illumination optical system and the display optical system share an optical curvature surface A having two functions of transmission and reflection with each other, a curved surface B is
10 provided on the opposite side of the optical curvature surface A to the display means, and the optical curvature surface A and the curved surface B compose a lens body, wherein rays emitted from the illumination
15 means are reflected by the optical curvature surface A of the lens body to illuminate the display means, and the reflected light from the display means is transmitted by the optical curvature surface A, is incident to the lens body, emerges from the curved
20 surface B, is reflected by a plurality of reflective surfaces, and thereafter is guided to the pupil to form an enlarged image of the image displayed on the display means, wherein in an outermost image on a local meridional section of the display means (a plane
25 including incident light and exit light of a reference ray emitted from the illumination means and passing a center of an image on the display means and a center of

Sub
C4
10015455.072701

Sub
C4
end

5 an eye), when an F3 eye center ray represents a ray passing the center of the eye and an outermost image height F3 on the far side from the eye and when an F2 eye center ray represents a ray passing the center of the eye and an outermost image height F2 on the near side to the eye, an optical path length of the F3 eye center ray in the lens body in the display optical system is longer than that of the F2 eye center ray.

10

28.
22. The image display apparatus according to Claim 21, wherein a curvature in the local meridional section of said optical curvature surface A of said lens body in said display optical system is larger than a curvature in the local meridional section of said curved surface B.

15

20

29.
23. The image display apparatus according to Claim 22, wherein optical path lengths in the lens body in the display optical system of eye center rays at respective image heights, passing the image heights and the center of the eye on the local meridional section of said display means, become gradually longer from said F2 eye center ray side to said F3 eye center ray side.

25

24. A head mounted display comprising the image display apparatus as set forth in either one of Claims

98

1 to 4, 6 to 10, 12 to 15, and 18 to 23.

~~8.~~
25. A head mounted display comprising the image display apparatus as set forth in Claim 5.

5

~~16.~~
26. A head mounted display comprising the image display apparatus as set forth in Claim ~~14~~ 17.

~~25.~~
27. A head mounted display comprising the image display apparatus as set forth in Claim ~~16~~ 17.

10

~~26.~~
28. A head mounted display comprising the image display apparatus as set forth in Claim ~~17~~ 17.

00915455-000701
EST-1560

add a2
addcs